



Whiting Petroleum Corporation

Petroleum Engineering Requirements for Horizontal Well Spacing Unit Determination

**Moroni 11M-1107
SWSW Section 11, T15S R3E
Sanpete County, Utah**

Tununk Formation

March 25, 2015 R. Nelms

◆ Volumetric Calculations

- ◆ Calculates the original and recoverable oil and gas in place
- ◆ Input requirements are the initial reservoir pressure, porosity, water saturation, gross pay, net pay, reservoir temperature and hydrocarbon PVT analysis as well as the drainage area and recovery factor from the Rate Transient Analysis.

◆ Economic Analysis

- ◆ Calculates ultimate recovery of oil and gas at the economic limit. Calculates net present value, cash flow, payout and return on investment at current, or future, oil and gas prices
- ◆ Input requirements are tangible and intangible drilling, completion and operating costs, taxes, interests, and the production type curve from analogy wells or RTA analysis.

◆ Rate Transient Analysis

- ◆ Calculates the effective fracture half length (X_f), effective permeability to oil and gas, number of stages producing, effective horizontal lateral length, dimensionless fracture conductivity (F_{cd}), reservoir drainage area as well as the recovery factor.
- ◆ Requires installing surface and downhole pressure gauges. Monitors down hole pressure and production performance under post frac stabilized production conditions for up to 6 months.
- ◆ X_f determines the distance between the existing horizontal lateral and lease lines, or offset infill laterals, to protect correlative rights and prevent waste.
- ◆ X_f determines the number of wells that can be drilled in the drilling and spacing unit based upon the economics and reservoir characteristics.
- ◆ When offset future horizontal wells are drilled it is possible to confirm the initial RTA analysis results with interference testing.

Example of RTA Fracture Half Length X_f and Keff Oil Analysis COGCC Cause 535 Docket 1307-AW-36 August 2013



Figure E-8-1: Example of Rate Transient Analysis Production and Pressure History Plot for 640-acre Wildhorse 16-13H Niobrara B Horizontal Well in Section 16 T9N R59W.



Figure E-8-2: Summary of Whiting Rate Transient Analysis on four Niobrara B Wells Showing Fracture Half Length (X_f) of 105 feet or less

Whiting Niobrara B RTA Results Summary					
R NELMS 1 21 2013					
WELL NAME	Drilling Unit	WELL LOCATION	DATE of TEST	Keff Oil of Micro-Darcies	X_f Feet
Wildhorse 16-13H	640	SEC 16 T9N R59W	6/30/2011	17	50
Two Mile 22-13H	640	SEC 22 T11N R57W	8/16/2011	17	85
Horsetail 18-0733H	960	SEC 18 T10N R57W	2/7/2012	12	105
Wolf 35-2623H	960	SEC 35 T10N R59W	2/29/2012	3	100

X_f = Effective Hydraulic Fracture Half Length in feet
(See Drawing below published by Fekete and Associates)

Fracture Half-Length (X_f)

A hydraulic fracture is typically modeled by assuming it extends in a straight line equally on each side of the wellbore as shown in the following diagram.

As shown, the fracture half-length is the distance from the well to the tip of the fracture.